This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Eng 809.03

Harvard College Library

FROM

Museum of Comparative Zoology

GODFREY LOWELL CABOT SCIENCE LIBRARY

Eng 809.03

REPORT

ON

CONCRETE FOUNDATIONS FOR PAVEMENTS

WITH SPECIAL REFERENCE TO WORK OF THAT NATURE

IN THE

BOROUGH OF BROOKLYN

CITY OF NEW YORK

DURING THE YEAR

1902

BY THE

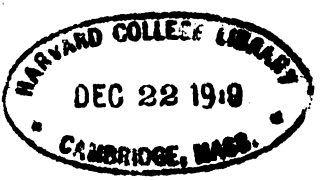
COMMISSIONERS OF ACCOUNTS

MAY 15, 1903

NEW YORK:
MARTIN B. BROWN CO., PRINTERS AND STATIONERS,
NOS. 49 TO 57 PARK PLACE.

1903.

Eng 809.03



Museum of Comparative Zoology

TELEPHONE "4315 FRANKLIN."

OFFICE OF THE

COMMISSIONERS OF ACCOUNTS,

ROOMS 103, 104, 105, 115, 119 & 121.

STEWART BUILDING,

280 BROADWAY.

WM. HEPBURN RUSSELL,
EDWARD OWEN,
Commissioners.

NEW YORK, May 15, 1903.

SUBJECT: *Report on concrete foundations for pavements with special reference to work of that nature in the Borough of Brooklyn, City of New York, during the year* 1902.

Hon. SETH LOW,
Mayor:

SIR—We herewith transmit to you a report made by our Engineering Bureau on the composition of concrete and the quality of its constituents used in street paving in the Borough of Brooklyn.

The various tests and analyses described therein have been carried on in our Physical and Chemical Laboratory during the last winter alongside of the regular routine business, as time would permit, and we consider the findings and conclusions of importance.

Respectfully submitted,

WM. HEPBURN RUSSELL,
EDWARD OWEN,
Commissioners of Accounts.

SUBJECT: *Report on concrete foundations for pavements with special reference to work of that nature in the Borough of Brooklyn, City of New York, during the year* 1902.

Hon. COMMISSIONERS OF ACCOUNTS,
New York City:

GENTLEMEN—During the past year (1902) an exceptionally large number of contracts for repaving streets with various materials, on a concrete foundation, were let in the Borough of Brooklyn.

The clauses of the specifications, which relate to the composition of the concrete and the quality of its constituents, are the same in all the contracts herein referred to, and are herewith quoted:

"14. *Concrete*—The concrete shall be made of the "best quality of Portland cement, samples of which "must be submitted at least ten (10) days (Sundays and "holidays excluded) before using, for the inspection "and approval of the Chief Engineer. All cement "shall be of uniform quality, color and weight, and "briquettes of one (1) square inch section shall develop "or exceed the following tensile strength:

"Neat—one hour in air, twenty-three (23) hours in water	200 pounds
"Neat—one day in air, six (6) days in water	400 "
"One of cement, three (3) of sand, one day in air, six (6) days in water	150 "

"The concrete shall be composed of one (1) part of "cement, three (3) parts of sand and six (6) parts of "broken stone. The unit of measure shall be the barrel of cement as packed by and received from the "manufacturer.

"The sand shall be clean, coarse and sharp, and be "free from loam or dirt. The broken stone shall be "of trap, granite or limestone, or such other stone "taken from the line of work as shall be satisfactory in "the judgment of the Engineer. It shall be entirely

" free from dust and dirt and be of graded sizes such " that all will pass through a revolving circular screen " having holes two and a half (2½) inches in diameter, " and be retained by a screen having holes one-half (½) " inch in diameter. The sand and stone shall be placed " upon board platforms and be kept free from dirt, and " the cement shall be properly blocked up and pro- " tected from dampness.

" The sand and cement shall be mixed dry, then made " into mortar by the addition of water, when the broken " stone shall be added and the whole mass thoroughly " mixed. The concrete shall then be spread upon the " subgrade and rammed so as to fill all the voids of the " stone with mortar and bring the surface exactly — " inches below the finished pavement. If a machine " be used for mixing, the above operation may be " varied as may be required. No concrete shall be used " that has been mixed more than one-half hour. The " concrete shall be protected from the weather when " deemed necessary by the Engineer.

" No horses, carting or wheeling shall be allowed on " the concrete before the same has set, except on planks " furnished and laid by the Contractor.

" The concrete foundation shall be six (6) inches " thick, except where otherwise specially ordered.

The severe and persistent criticism of the Examining Inspectors and Engineers of this office in regard to the concrete foundations on many of these contracts points to the conclusion that much of the concrete thus laid in Brooklyn during the past season is of poor quality, and is not of the character that a strict enforcement of the specifications regarding its constituents would compel.

That this conclusion is altogether correct is strongly evidenced by the action that the Bureau of Highways of the Borough of Brooklyn has been compelled to take within a comparatively recent period, namely, to require the contractor to replace either a part or the whole of the concrete he had laid, notwithstanding the fact that the cement used

had been passed by the Bureau of Highways, and the work had been under its constant daily inspection from inception.

The criticism of this office has included almost every item mentioned in the portion of the specifications quoted above, as well as the quality of the concrete itself, of which no mention is made in the same.

By this it is not meant that the specifications were violated in every respect on every contract, but rather that there were few contracts where no item of this Concrete clause was violated, and a large number where many were violated.

To begin with, I will call your attention to the quality of the materials of which the concrete in general which has been criticised is composed.

The broken stone is usually free from dust and loam or dirt, although some exceptions to this have been noted, but in addition to being free from dust the broken stone is usually also free from the smaller sizes (½ inch to 1¼ inches in diameter) of stone which are of the greatest value in filling the voids between the larger stones. The reason for this lack of smaller stones is that oftentimes they are screened out to be used for the binder of asphalt pavements. The trap and limestone crushed and screened at the quarry are usually satisfactory, except in this respect, but the specifications allow of the use of any stone taken from the line of the work which shall be satisfactory to the Engineer, and this opens the way to the use of large quantities of stone, usually old cobble pavements, parts of which are altogether unfitted for concrete, since much of it is of a particularly inferior quality. Then, in addition, the contractor does not pay the amount of attention to the crushing which he would do if he had to market his product, and once his crusher is set up, he is not particular as to whether his source of supply is limited to the stone on the line of the work or not. The result is that the broken stone as brought to the work is a vari-colored mixture of stone of all descriptions containing almost invariably a considerable percentage of stone greatly exceeding the specified limit of 2½ inches, and from which nearly all of the finer stone (that is less than 1½ inches

diameter) has been removed. The stone is usually placed on board platforms as required.

The sand, however, is almost invariably dumped from the carts directly onto the ground forming the sub-grade of the street, and is seldom placed on boards before it reaches the mixing board. The sand is usually fairly clean and sharp, but might be coarser to advantage.

The cement, which is, of course, by far the most important ingredient of the concrete, is required by the specifications to be the "*best quality* of Portland Cement," and if this requirement were strictly enforced, there would be little to criticise, aside from what has been previously mentioned.

The minimum limit required for the tensile strength of briquettes of one square inch section is so low, however, as to permit of the use of second-quality cement, and it is an unfortunate fact that if a cement passes these easy tests it is usually accepted by the Bureau of Highways without any further examination as to its classification as a Portland Cement of the *best quality*. It is a well-known fact that there are many cements which show excellent results when tested neat, and fail miserably in a mortar test ; that is, when mixed with sand.

The latter is obviously the most important and conclusive test of a cement which is to be used for concrete, and the fact that there are certain cements on the market which will just about pass muster on the basis of the tensile strength required by the specifications, and yet when made into concrete provide about as poor a quality of the same as is deserving of the name, leads me to believe that the specifications are too low in their requisition of tensile strength, particularly in the mortar tests. With any well-recognized brand of "best quality Portland Cement," no difficulty is experienced in maintaining the tensile strength of mortar briquettes mixed in the proportions of one part of cement to three of sand, at an average much higher than the figure asked for by the specifications.

The clause quoted in the first part of this report states that "the concrete shall be composed of one part of

cement, three parts of sand and six parts of broken stone. The unit of measure shall be the barrel of cement as packed by and received from the manufacturer."

It is seldom, if ever, that cement in barrels is seen on these contracts. The universal custom seems to favor the use of cement in bags supposed to contain a quarter of a barrel. This, I understand, is largely a matter of economy with the contractor since cement in wood is sold at an advance of 25 cents per barrel to cover the cost of same without a rebate for the return of the empty barrels, whereas the bags are charged for at the rate of 10 cents each, all of which is rebated with the return of the bags. It will be seen that the contractor thus effects a considerable saving in a contract of any size by the use of cement in bags.

It is also probable that the facility with which packages of this size may be handled is partly responsible for this condition, rather than a preference to mix in smaller quantities, since it often occurs that four bags of cement are used in the mixing of one batch, especially when the same is done by hand. There is a decided advantage to be gained, however, by the use of cement in barrels due to the superiority of the barrel over the bag in protecting the cement from careless handling, dampness and the inclemency of the weather, as, in spite of the specifications, the cement is seldom properly blocked up and the protection from rain and dampness is rarely adequate.

The measurement of the proportions for the concrete is subject to considerable variation on different contracts, three different units having been used on some work, one for each class of material. Probably 75 per cent. of the contractors who mix their concrete by hand measure the proportion as follows, using these quantities of each class of material, or convenient multiples of the same :

One bag of cement, one wheelbarrow of sand and two wheelbarrows of stone.

When three bags of cement are emptied into a wheelbarrow, they fill it so that the barrow presents the appearance of being well filled but not heaped. Consequently, if the sand

and stone barrows were loaded to the same height, the resulting concrete would approximate the proper proportions presumably close enough to guarantee a good concrete, provided the cement was of the *best quality* and all other details were properly attended to.

But it is not unusual to find the barrows heaped up to their fullest capacity, particularly those containing sand, which, being damp, can be packed until the load sometimes contains enough sand to make the proportion nearly one to four instead of one to three.

When mechanical mixers of the type generally used in Brooklyn, are employed, it becomes impossible to accurately measure or maintain the proportions of the constituents of the concrete. The machines mentioned may be described as consisting essentially of a shaft to which are attached at intervals blades or paddles whose faces are inclined at an angle to a plane at right angles to the axis of the shaft, in such a manner that when the shaft is made to revolve in the trough in which it is set, any material thrown into the trough at one end is forced by the blades to travel toward the opposite end, where it is discharged, the material being also turned over and mixed to a certain degree by the action of the blades during its progress through the trough. This type of mixer is known as a continuous mixer from its action in continuously discharging the mixture as long as it is fed with material. The features which make this style of machine attractive to contractors are obvious. There are, however, serious objections to its use from the point of view of the other party to the contract, namely, the City. A brief description of the manipulation of these mixers readily discloses a number of these objections. To begin with, the machine, which for street work is of the portable variety, is placed in position in close proximity to a pile of broken stone; the sand and cement are then mixed on platforms on the opposite side of the machine from the stone, in the proportions of one bag of cement to a wheelbarrow of sand. The mixing of the cement and sand (dry) is seldom if ever thoroughly done, although this is a matter of prime importance for securing

good results. The mixed sand and cement are then shoveled into the machine from one side, by two men usually, while from six to nine men stand on the other side of the machine and shovel in the broken stone.

The man who controls the discharge of the mixture also regulates the flow of the water which is admitted to the trough through small holes in pipes surrounding the same. The continuous discharge can be interrupted at the pleasure of the operator by means of a sort of flap operated by a lever by which the mouth of the machine may be closed for short periods limited by the rapid accumulation of material at that end, but sufficient to allow for the substitution of an empty barrow for one that has just been filled (this being the usual method for the distribution of the concrete). It is obvious from the preceding description that it is absolutely impossible for any one, even with the best of intentions, to measure even approximately the proportions of the materials introduced into the trough, and the difficulty of maintaining any fixed proportion whatever, is also very evident, while the ease and facility with which a contractor, so minded, can slight his work under the very nose of an inspector will go far toward accounting for the popularity which this style of mixer enjoys among contractors.

It is freely admitted, even by the contractors themselves, that the operation of such a machine when the best possible results are to be obtained, requires the undivided attention of a competent foreman thoroughly experienced in the management of the machine. The number of men employed in shoveling in the materials, the amount of the different classes of the material that can be held on a shovel, the rapidity and regularity with which the men work, and the tendency of the contractor to slight his work or to do it properly are all variable factors in proportioning the material. Again it is plain that six or seven men shoveling stone on one side of a trough about eight feet long cannot, without great inconvenience and delay, all throw the material they are handling into the upper end of the trough from very lack of working room, and must, perforce, throw the same

in at the point nearest them; and this fact, coupled with the difficulty of admitting the proper amount of water results, except under the most favorable conditions, in the discharge of concrete, which is sometimes too wet and sometimes too dry, or one wheelbarrow may contain an excessive proportion of broken stone and the next an excess of mortar. When deposited, the non-uniformity of the concrete becomes more apparent since a slight amount of tamping on the batches that contain more mortar than is needed quickly flushes the same to the surface—while producing almost no effect on the batches lacking in mortar save to compact the same. Under these circumstances, the mortar which appears on the top of a wet batch is swept by a broom on to any adjoining patch which may be dry, and a uniform appearance is thus produced, which is very deceptive and not at all representative of the character of the concrete beneath it.

It must not be inferred from the foregoing that objection is made to machine-mixed concrete, or that hand-mixed concrete is preferred. In fact, quite the reverse is true, provided the type of machine be one which allows for the mixing of the concrete in batches instead of continuously. I am unalterably opposed to the use of any kind of continuous mixer for the reasons shown by the preceding discussion, but I am equally in favor of the use of any type of machine that mixes in batches and provides a uniform and thoroughly mixed concrete, where the amount of the different materials used can be accurately measured and proportioned, and where inspectors can readily check, at any moment, the measurement of the same. There are on the market to-day several types of machines where all of this is possible, and in some of them as rapid work can be done as with the other style of mixers, while the resulting concrete is uniformly and thoroughly mixed to a degree that I have never seen attained by the continuous mixer.

It is a fact that on all the work in Brooklyn, where the concrete has not been satisfactory to this office, usually

owing to its failure to set properly, either Atlantic or Invicta Portland cement has been used.

Invicta cement (formerly named Victor cement) has been used in nearly 30 per cent. of all the concrete foundations of paved streets in the five boroughs of Greater New York which have been examined by this office during the last three years. Its use for that purpose is *almost entirely confined to the Borough of Brooklyn*, and during the *past year* it has been used in that one borough on *as many contracts* as any other brand of cement has been used in *all the boroughs* for the *past three years.* The contractors who have used the Victor or Invicta cements on more than two contracts that have been examined by this office during the last three years are: The Inter-State Paving Company, Cranford Company, Eastern Bermudez Company, Brooklyn Alcatraz Company, and Cunningham & Kearns Construction Company. Of the above-mentioned contractors, the Inter-State Paving Company is the only one which has used Invicta cement exclusively. Such extensive use of a brand of cement by leading paving contractors is a high compliment to the ability of the sales agent, if indeed it has not a deeper significance.

The Glens Falls Portland Cement Company manufacture three brands of cement, which are graded as follows, in respect to price and quality:

1st—Ironclad.

2d—Invicta.

3d—Adirondack.

The Ironclad cement is a first-class cement in every respect. The other two brands are made from the same materials, I understand, except that they contain certain percentages of finely-ground unburned cement rock. This fact, as determined in the laboratory of this office, is acknowledged by the manufacturers.

To the average lay mind, the explanation of such adulteration or dilution of a good cement by the addition of a finely-ground inactive material would not be much more difficult than to explain the reason for a grocer introducing

sand into his sugar barrel—to obtain an article which he could sell at a lower price and still retain enough of the characteristics of sugar to answer certain purposes.

The manufacturers, however, claim that the introduction of the unburned cement rock during the process of grinding the burned product permits of a finer grinding of the whole mass than would otherwise be possible—the value of a finely-ground cement being well recognized.

However that may be, the fact remains that even though the value of the active cement be thus increased (a point which I am not prepared to argue), there still remains in the mixture a large amount of a very finely-ground material, physically and chemically inactive, as far as its cementing properties go, and representing nothing more valuable in the cement, after it has been ground, than so much very fine sand, and in a concrete, nothing more than so much extra sand, so fine that no engineer would ever allow a contractor to use it in concrete if it were separate from the cement.

In this connection, I wish to quote a pertinent article from "A Treatise on Highway Construction," by Austin T. Byrne, C. E.

Page 273:

"504. *Fineness of Sand*—Vicat, in the course of "elaborate experiments with limes and mortars in the "early part of this century, established standards for "size of grain of what he termed coarse sand and fine "sand, as follows: coarse sand being such as will pass "through a sieve of 64 meshes per square inch and be "retained on one of 289 meshes per square inch, while "fine sand will pass through a sieve of 289 meshes per "square inch and be retained on one of 625 meshes per "square inch. On this definition he ranked the superi-"ority of coarse, mixed and fine sands with limes ac-"cording to the following schedule:

"For eminently hydraulic limes, 1, fine; 2, mixed; 3, "coarse.

"For slightly hydraulic limes, 1, mixed; 2, fine; 3, coarse.

"For fat or quick limes, 1, coarse; 2, mixed; 3, fine.

" It will suffice to say that with cement-mortars much " better results are obtained when the sand is of the " size of grain above described and is sharp and clean.

" Mr. Clark says that when the sand was formed of a " mixture of fine and coarse grains, nearly as good re- " sults were attained as with coarse grains alone.

" Before leaving this subject, it may be of interest to " refer briefly to the experiments made at Wilhelms- " haven in 1877, by H. Arnold, C. E., as published in " the Journal of the Hanoverian Architects and Engi- " neers' Society for 1883, and from which was found " that the size of grain and quality of the sand used in " Portland-cement mortar are important factors in its " ultimate strength. With six different kinds of sub- " stantially clean sands and the same brand of cement " mixed into mortar in the proportions of three volumes " of sand to one volume of cement, the tensile strength " after seven days ranged from 101 to 243 pounds per " square inch, and after twenty-eight days from 133 to " 311 pounds per square inch, thus exhibiting extremely " wide variations, depending largely upon the size and " roughness of the grains of sand.

" In every instance it was found that a greater strength " was developed with a coarse-grained sand free from " very fine particles and dust than with a fine-grained " sand, both being equally sharp. Mr. Arnold also " points to the fact deduced from his experiments, that " with the same cement but different sands of similar " size of grain, the cohesion of the mortar may be found " to vary considerably, and will probably depend upon " the chemical composition of the sand. He therefore " concludes that in order to obtain satisfactory results " from the cement-mortar used in the construction of " public works, the quality of the sand available in the " particular locality should first be taken into careful " consideration.

" If no other than a fine sand happens to be available " and a given strength of the mortar is to be attained at

" the end of one week, experiments should be made to " learn whether the proportions of sand to cement named " in the specifications should be changed, since the " strength diminishes rapidly with the quantity of sand " used ; and in such an event it may also be advisable " to use an entirely different kind of cement. It is a " necessary condition of success in mortar making that " every particle of the sand or "aggregate" be com- " pletely covered with the cement or "matrix," and " since, when the grains in a given volume are small, " the magnitude of the total surface to be covered is " greater that when the grains are large, it follows that " fine sand requires a larger proportion of cement than " coarse sand. Any specification or plan contemplating " the use of a good coarse sand must, therefore, be " altered if fine sand alone is used, or else the quality of " the work will be impaired.

" In support of the foregoing remarks, it has been " quite generally observed by engineers that when most " of our American natural cements are mixed entirely " with fine sand the process of hardening is greatly " retarded, even if not entirely prevented; while the " same cements, when tested neat, exhibit a cohesive " strength ranging from 50 to 136 pounds in twenty- " four hours, thus showing conclusively the effect of " admixing the fine material. An instructive instance " of this kind was noticed some years ago, when an " excellent quality of Akron 'Star' cement was mixed " with very fine sand from the Pinnacle pits in the pro- " portion of 2½ parts sand to 1 part of cement. For " several days the mass remained in a plastic state in " the tin can in which it had been deposited, and upon " being removed and exposed to the air upon a window " sill for several months it displayed very little strength " and broke in handling. On the approach of cold " weather, the largest fragment was kept in an apart- " ment constantly heated by steam, and after lying un- " disturbed therein for three months pieces could easily

" be broken off with the fingers. At the present time, " after having attained an age of one year, it is still quite " friable and entirely unfit for use. Another mass of " mortar prepared at the same time from the same " cement, but with clean, coarse sand, mixed in the " proportions of 3 parts of sand to 1 part of cement, " indurated promptly and exhibited far better qualities."

TABLE XLVIII.

Effect of Size of Grain of Sand on Tensile Strength of Cement Mortar.

Denominations of Size of Grains.	Tensile Strength of Mortar Mixed 3 : 1 with			
	Dangast sand after		Crushed granite after	
	7 Days.	28 Days.	7 Days.	28 Days.
Hulled barley	177	213	194	255
Oatmeal	162	191	176	234
Standard	131	177	164	242
Grass-seed	134	164	144	192
Grit	141	160	136	193
Coarse dust / Fine dust	64	87	87	134

TABLE XLIX.

Character of Sieves for Sifting Sands.

Number of Seive.	Number of Holes per Linear Inch.	Number of Holes per Square Inch.	Size of Hole of Length of Side in Inches.	Diameter of Wire in Inches.
1	20	400	.03101	.01899
2	30	900	.02119	.01214
3	50	2,500	.01119	.00881
4	80	6,400	.00599	.00051
5	170	28,900	.00309	.00279

A number of samples of concrete from streets in Brooklyn have been analyzed in this office, together with several cement mortars and cements, the results of which may be seen in tables A, B and C which accompany this report. Mere inspection shows that, in general, these samples have been of inferior quality, the mortar being soft and friable and easily separated from the stone, although certain exceptions have been noted.

In the examination of these concretes, it was first determined, as nearly as possible, what percentages by weight of stone and mortar, and of cement and sand, were required for an average concrete, made of one part of a first-class Portland cement, and three parts clean sharp sand for the mortar, which, when mixed with six parts of broken stone, clean and hard, forms a concrete of good quality.

The specifications require that the mixture shall be made by measure, and as all analyses are expressed in parts by weight, it was therefore necessary to determine the equivalents by measure, in percentages by weight. A number of experiments were made upon which to base this estimate. The unit measure of the specifications is a cement barrel and the mortar is to be made by adding to it three equal barrels of sand. A barrel of Portland cement weighs 380 lbs. net. Obviously, to get the weight of three barrels of sand, the capacity of a cement barrel must be known. This, however, is a variable quantity, owing to the fact that cements of different brands vary in specific gravity, and consequently in bulk for a given weight. Thus the capacity of Portland cement barrels ranges from 3.2 cubic feet to 3.8 cubic feet. The average of the barrels of some twelve brands of well-recognized first-class Portland cements shows a capacity of 3.34 cubic feet.

Seven samples of sand from dealers in this City who supply contractors were dried and carefully weighed, showing a range from 90 to 101 pounds per cubic foot, the average being 97.1 pounds per cubic foot.

Broken stone of the size commonly known as 1½ inches, containing 48 per cent. to 50 per cent. voids, was found to

weigh, when dry, approximately 92 pounds per cubic foot.

After a number of concretes had been analyzed air dry, it was found that the percentage of water in the air dried concrete must be determined at a constant temperature. It was also desirable that the whole sample should be dried at a constant temperature, in order that the proportions of stone and mortar might be comparable. An electrical oven was procured in which 2 to 3 kilograms of concrete could be dried at a constant temperature of 220 degrees Fahrenheit. The specimens still contained an average of combined water amounting to 4.5 per cent. of the mortar, or about 64 pounds of water to one barrel of cement.

Therefore the following table shows the composition of a good average Portland cement concrete to be as follows:

	Cement.	Sand.	Broken Stone.	Water.
Volumes	1	3	6	..
Cubic feet	3.34	10.02	20.04	..
Pounds	380.	973.	1844.	64
Per cent	11.65	29.84	56.55	1.96

Aside from the fact that these percentages are deduced from general averages, and may, therefore, show a variation from particular or individual instances, they are also subject to a certain modification for the following reason:

When an analysis of the concrete is attempted, the first step after drying the mass at 220° Fahrenheit is to effect a complete mechanical separation of the broken stone and mortar. By using a sieve of ten meshes to the linear inch, this separation can readily be made, the only source of error lying in the amount of gravel that is contained in the sand, and which, in practice, is never screened out. This error would increase the percentage of stone and diminish the sand in the mortar by a small and uncertain amount. Determined

by this method, the average percentage of stone and gravel in a concrete of good quality should amount to about 60 per cent., as against 56.55 per cent. in the above table.

This figure will vary with different cements possibly two per cent. with the same kind of stone. As the specific gravity of cements varies, and as also the specific gravity of the sand and stone to a less extent, the relative weights of a unit volume, or multiples thereof, will vary to a certain extent. It was found, however, that in those cases where the per cent. of the stone is highest and the cement lowest, that the cement is light from excess of unburned cement rock, which is evidently added intentionally for purposes of adulteration. An examination of the tables accompanying this report will show that the percentage of stone in the concretes ranges from 77 per cent. to 52 per cent. These figures exhibit a range of 25 per cent. So wide a difference is only to be accounted for on the ground of gross carelessness in mixing the concrete.

In order to establish a standard of comparison for the proper proportions by weight between the average first-class Portland cement and sand in a cement mortar, as shown by a chemical analysis, an estimate was made based on the analyses made in this office of seven first-class American Portland cements, and also a determination of the soluble portion of the sand in general use in the preparation of concrete mortars about the city. The average composition of these seven cements is given in No. 1, Table A. The per cent. of mortar there found insoluble in 10 per cent. HCl is 4.38 per cent. The average amount of sand soluble in 10 per cent. HCl, was found to be 1.07 per cent. From these figures, and on the basis that the mortar contains

1 vol. dry cement, 3.34 cubic feet.....	380	pounds.
3 vols. dry sand, 10.02 " "	973	"
Water in combination, 4.5 per cent...	64	"
Total weight of mortar.....	1,417	pounds,

the percentages of matter, soluble and insoluble, in the mortar are readily deduced as follows:

	Soluble.		Insoluble.	
Cement, 380 pounds.....	(95.62%)	363.35 lbs.	(4.38%)	16.65 lbs.
Sand, 973 "	(1.07%)	10.41 "	(98.93%)	962.59 "
Total..		373.76 lbs.		979.24 lbs.
Per cent of mortar...		26.37 per cent.		69.13 per cent.

The composition of average cement mortar as thus found is:

Insoluble in 10 per cent. HCl.....	69.13	per cent.
Soluble " 10 " "	26.37	"
Volatile at red heat.....	4.50	"
Total	100.00	per cent.

Of the 26.37 per cent. of the mortar that is soluble in 10 per cent. HCl. there are certain constituents which go to form the active principle or cementing power of the mortar or concrete. These, of course, are principally contained in the cement and consist of soluble silica, alumina and iron oxide and lime.

The proportions of these ingredients in terms of percentages of the *mortar* were determined as follows, by using data obtained from previous work in this line, thus:

An average of the analyses of the seven first-class Portland cements previously referred to showed the proportions of the above-mentioned ingredients to be, in terms of percentages of the *cement:*

Soluble Silica.....	18.45	per cent.
Alumina and Ferric Oxide....	9.46	"
Lime.....	61.89	"

Analysis of the sand for the same purpose gave in terms of percentages of the *sand* :

Soluble Silica.....	0 25	per cent.
Alumina and Ferric Oxide....	0.23	"
Lime.....	.06	"

In both the cement and the sand there are, of course, other ingredients either insoluble or inactive which need not be considered in this connection.

Then if we consider, as before, that a Portland cement mortar (1 to 3 by volume) will contain 380 pounds of cement, 973 pounds of sand and 64 pounds of water in combination, the quantities of the soluble silica, alumina and ferric oxide and lime in the mortar will be as follows:

	Soluble Silica.	Lbs.	Al. and Fe. Oxides.	Lbs.	Lime.	Lbs.
From Cement..	(18.45% of 380)	70.11	(9.46% of 380)	35.95	(61.89% of 380)	235.18
From Sand	(0. 25% of 973)	2.43	(0. 23% of 973)	2.24	(.06% of 973)	0.58
		72.54		38.19		235.76

Which in percentages of *mortar* amount to:

Soluble Silica.....	5.12	per cent.
Alumina and Ferric Oxide.....	2.70	"
Lime	16.64	"
Making a total of.....	24.46	per cent.

—which subtracted from 26.37 per cent. (the entire amount soluble in 10 per cent. HCl. as shown in the schedule on page 20), leaves 1.91 per cent. of the soluble matter which is inactive, consisting of magnesia, sulphuric oxide, alkalies, etc.

A summary of the results obtained from the preceding calculations then shows that a good average Portland cement concrete, in the proportions of 1 to 3 to 6 by volume, should give in percentages by weight approximately:

- Concrete
  - Broken Stone, 56.55% to 60%
  - Mortar consisting of cement, sand and water in combination, 40% to 43.45%
    - Insoluble, 69.13%
    - Volatile at red heat, 4.50%
    - Soluble, 26.37%
      - Inactive, 1.91%
      - Active, 24.46%
        - Soluble Silica. 5.12%
        - Alumina and Ferric Oxide 2.70%
        - Lime.....16.64%

These results are arranged in sequence in Table B, No. 100, and Table C, No. 310, to which comparative reference will be made later.

When some months since a number of cements were analyzed in this laboratory, it was found that the seven first-class American Portland cements previously mentioned gave results that very closely approximated the theoretical requirements of Newberry's formula, which is:

$$\frac{2.8\ (\textit{Soluble Silica}) + 1.1\ (\textit{Alumina and Iron Oxide})}{\textit{Lime.}} = 1$$

According to this formula, these seven cements equaled .997—practically 1. In these seven cements, the sum of the percentages of soluble silica, alumina and iron oxide taken together, and lime, was 89.9, practically 90 per cent.

The approximation of the above figures to the results actually obtained in analysis can be found by comparing No. 1, Table A, with any of the other analyses numbered 2 to 9, all of which are analyses of first-class cements. An instructive comparison can also be made between these cements and Nos. 10 and 11, Table A.

In order to ascertain to what extent these figures, shown on page 20, are confirmed by the practical work of the laboratory, briquettes were made of a first-class Portland cement, with standard crushed quartz (Analysis No. 120, Table B), and also with a quartz sand in very general use in concrete constructions about the city (Analyses Nos. 130 and 140, Table B). The cement was first analyzed (No. 3, Table A); when the briquettes were analyzed, the first contained 68.19 per cent. insoluble in 10 per cent. HCl., the second 68.07 per cent., and the third 69.55 per cent. A fourth briquette (No. 150, Table B) was made from mortar taken from a mortar board where cement concrete was being mixed by hand. This mortar, when air-dried, contained 71.3 per cent. of matter insoluble in 10 per cent. HCl. Another briquette (No. 160, Table B) from a mortar made of another cement contained 72.14 per cent. insoluble in 10 per cent. HCl. The average insoluble matter in these five mortars is 69.85

per cent. It is probable that with different sands and cements, and for practical purposes, an average of 70 per cent. would not be far from correct. The average amount of active cement found in these five cement mortars by Newberry's formula is 23.17 per cent.

A specimen of Invicta cement, which is admitted by the manufacturers to be adulterated with unburned cement rock, was analyzed, and the results are given in No. 11, Table A. These results indicate that this sample was somewhat better than the sample of the same brand, the analysis of which is given in No. 10, Table A. In the latter the amount volatile at a red heat is 22.31 per cent.; in the former 19.57 per cent. A briquette made from the sample No. 10, Table A, and the same sand as was used in the ones numbered 140, 150 and 160, Table B, was also analyzed. In two samples of the sand the total amount soluble in 10 per cent. HCl. was practically the same (1.07 per cent.), but all of the ingredients dissolved from the two samples varied in their relative amounts quite widely. It is evident that the quartz contains a fraction of one per cent. of feldspar and a larger fraction of iron oxide, neither of them of practical importance, and at the same time sufficient to modify by a few hundredths per cent. the results of the analysis of a concrete when compared with the analysis of a cement from which the concrete was made.

In all of these samples of concretes and mortars made from cement (Nos. 10 and 11, Table A) there is an excess of lime, amounting in some instances to half the lime found, which is over and above the amount of lime required to form with the soluble silica an active cement, according to Newberry's formula. This excess represents a certain amount of carbonate of iron or unburned limestone in the cement originally. It is not necessary to discuss here the theoretical value of the formula. As an empirical formula, it has been found to indicate in instances, now amounting to hundreds, the value of a cement for practical purposes, in a most satisfactory manner. An examination of the figures in No. 1, Table A, will show that the alumina and ferric

oxide taken together are almost exactly one-half of the amount of soluble silica. The figures in this number give the average composition of the seven American Portland cements analyzed in 1901, and previously referred to. These figures are found to almost exactly represent Newberry's formula, and are a most convincing proof of its practical value.

In order to determine the percentages by weight of soluble silica, alumina and iron oxide taken together, and lime, the sum of which percentages indicates the entire amount of active cement in any cement mortar or concrete, according to Newberry's formula, verified by a large number of analyses, many of which are represented in the accompanying tables, it was assumed that no injustice would be done in any comparison that might be made if the soluble silica was used as a unit of comparison after the following manner: The sand used was a clean quartz containing about one per cent. of iron oxide and other matter, which was soluble in 10 per cent. HCl. The amount so soluble was sufficient to increase the percentages of alumina and iron oxide present, but the amount of sand used in the mortar being very variable, the amount of iron accruing from this cause was inconstant. It was therefore determined to assume on the basis of the average results represented in No. 1, Table A, that the amount of alumina and iron oxide legitimately constituting the active cement present shall be computed at one-half the soluble silica present. Then, using Newberry's formula, and multiplying the percentage of soluble silica by 2.8, and one-half of that percentage by 1.1, and adding the products together, the sum thus found represents the percentage of lime that, in combination with soluble silica, alumina and iron oxide, formed the active cement present. The soluble silica found by analysis, plus one-half such amount computed as alumina and iron oxide, plus the lime computed as above indicated, equals the percentage of active cement found in any concrete.

After this manner the "Per Cent. of Active Cement by Newberry's Formula," the "Per Cent. of Excess of Lime as

Carbonate," and "The Ratio of Cement found to that required," have all been computed.

Several very important considerations are manifest upon an examination of Tables B and C. Of the eight briquettes in Table B made under varying conditions and the two mortars taken from streets, the numbers 120, 130 and 140 are strikingly near the estimated composition of cement mortar, made as above described, which is given in detail in No. 100.

In Nos. 150 and 160 the street mortars were made with a cement of good quality and a slight excess of sand. The remainder of the numbers represent mortar made from the cement, the analysis of which is given in Nos. 10 and 11, Table A, and which is largely adulterated with unburned cement rock. The low content of soluble silica amounting to half or less than half that found in Nos. 120–160 indicates the inferior quality of mortars made from such cements.

In Table C are arranged analyses of 26 samples of concretes taken from streets in process of construction during the last season. No. 310 represents the estimated composition of concrete made of 1 part first-class Portland cement, 3 parts sand and 6 parts broken stone, each of good quality. The 26 concretes that follow it are arranged according to their content of soluble silica. This ingredient is considered to be, other things being equal, the essential constituent of a Portland cement.

Nos. 320 to 380, inclusive, represent concretes made from cements of good quality.

All the concretes in the list from No. 390 to 570, inclusive, were made with mortar that effervesced freely when placed in 10 per cent. hydrochloric acid as well as the cement from which the mortar is made. No first-class Portland cement ever effervesces when subjected to the action of 10 per cent. HCl. nor does mortar made therefrom.

In most of them the stone was of good quality, but too exclusively in large pieces, the small stone having been apparently screened out for binder. In the others, the stone

consisted of crushed paving stones from the drift gravel pits of Long Island and contained badly decomposed slate and granite, in some instances softer than the very soft mortar.

The samples of concrete (530, Table C) and (480, Table C) were both made from Atlantic Portland cement. The use of this cement, I understand, has been *discontinued by order of the Brooklyn Bureau.* It will be noticed how closely the analyses of these two samples agree with the average analysis of concrete made from *Invicta cement.* The question that might be raised here is apparent, when it is understood that nearly all of the concretes analyzed have been taken from work characterized by its weakness.

The contracts from which these samples were obtained are not by any means the only ones where the required proportions of materials other than cement have been exceeded, but as it happens in nearly every other instance, the cement used has been of such a character as to be able, apparently, to withstand the bad usage that it is compelled to undergo and still provide a fairly good concrete. A series of experiments to determine to what extent this may be true was started quite recently in this office, but unfortunately the arrival of winter, since it practically puts a stop to the laying of concrete, has prevented the prosecution of the experiments to a degree sufficient to warrant the drawing of conclusive opinions. The idea was as follows: Briquette moulds were taken to a street where concrete mixing was in progress, and the moulds were filled directly from the mixing-board. Samples of the cement and sand in use were obtained at the same time and were mixed in the proper proportions at the office and placed in moulds. Some of the cement was also made into briquettes with the standard crushed quartz sand used in testing cement, and the results of the tensile strength of all these briquettes, which were allowed to set for seven days, were compared. As stated above, the scope of the experiments was too limited to draw definite conclusions, but indications seemed to point to a possible deduction that an Invicta cement which would pass the requirements of the specifications in the office, would

only show a tensile strength of a little more than half the required amount when taken from the work; while other brands of cement, although somewhat weaker when taken from the work than was developed by tests in the office (as was to be expected), still were of sufficient strength to pass the requirements by considerably more than a liberal margin and produce a correspondingly good concrete. The analysis of such a briquette of Invicta cement mortar, placed in the mould on the street, is shown in No. 210, Table B, while in Nos. 150 and 160 of Table B will be found the analyses of two briquettes made under similar conditions from other cements of good quality, namely, Trowel and Condor brands. A comparison of these analyses goes far toward showing the reasons for the difference of behavior in the physical tests; the Invicta briquette having a tensile strength of only 76 pounds per square inch, while the Trowel and Condor briquettes broke at 195 pounds and 180 pounds respectively.

No. 170, Table B, gives the analysis of a mortar briquette of Invicta cement mixed in the office in the proper proportions with sand from the street where the cement was used. This analysis may be compared with that shown in No. 130, Table B, which is the analysis of a briquette mixed under the same conditions, but made of Atlas cement.

It is my intention to continue this line of experiments next season under all the conditions which may obtain on the contract work of the City where concrete is used.

The concrete on one of the Brooklyn contracts was commenced by the employment of a Drake mechanical mixer, the use of which was shortly afterward prohibited by the Brooklyn Department. The concrete mixed by this machine was exceptionally bad, was not as firm as a poor macadam pavement, had almost no cohesive strength and could be easily removed with a pick. Its character being perfectly apparent, the patchwork remedy was also applied here, where the proper course should have been the entire removal of all the poor concrete.

Hand mixing was instituted after the use of the machine

had been prohibited, and in general the concrete was afterward fairly well mixed and laid, with a tendency, however, to an excessive use of water in mixing.

An inspection of concrete that had been laid about a week showed that the same was not as hard as might have been expected under the conditions stated. An examination was also made of two pieces of concrete which had been removed from the work, owing to a mistake in the grade, and which at that time were about a month old.

These could be quite easily broken by comparatively slight effort, the stone coming away from the mortar clean. The tensile strength of the mortar could not have exceeded 100 pounds per square inch. In No. 550, Table C, of the tabulated analyses, is shown that of a sample of the machine-mixed concrete. Nos. 490, 430, and 440, Table C, are analyses of three samples of the hand-mixed concrete from various locations on the work, and the sample (No. 210, Table B) is a briquette made from mortar taken from the mixing board and placed directly in the moulds. The tensile strength of the same was only 76 pounds per square inch.

During the early winter of 1902–1903, a considerable amount of concrete was laid when the temperature was such that the concrete was extremely liable to be impaired by the action of frost, and in fact the concrete, on some streets, otherwise of excellent quality, was badly disintegrated for such reasons. This is a condition of affairs which occurs nearly every year, and it would seem that the remedy is very simple. By opening bids at an early date in the spring, the work could be ordered ahead in plenty of time to complete 99 per cent. of the contracts before cold weather, and work on the remainder could easily be stopped at the order of the Bureau, as few paving contracts of such magnitude as to continue more than seven months are executed. Moreover, it is an unnecessary hardship on the contractor as well as a detriment to the work, since he is compelled to protect his work from freezing and still guarantee its quality.

In my opinion, the specifications for the concrete are lacking in several respects.

First—While they specify the character of the several constituents, they specify nothing whatever as to the character of the *concrete itself*, which is the all-important material.

Second—The "best quality of Portland Cement" will not contain over 6 per cent. of matter insoluble in 10 per cent. Hydrochloric acid or volatile at a red heat, and these conditions might well be included in the specifications. Also no "best quality" cement would be excluded or injured in competition if the requirements for tensile strength were raised. This is most plainly evidenced by the present specifications themselves in the clause giving the requirements for concrete curb, as is shown by the following comparison:

Cement Requirements.

	For Concrete.	For Concrete Curb.
1 Day Neat.....	200	225
7 " "	400	500
7 " Mortar.....	(1-3) 150	(1-2) 225

While it is true that the requirements for the 7-day mortar tests are not comparable, since they contain different proportions of sand, it is readily seen that if the tensile strength for the neat cement may be raised, the same may be done with the mortar.

Third—A great improvement in the control of the measurement of the proportions could be made by specifying weight of cement to cubic feet of sand and stone, and on the basis of the previous discussions, I would recommend amounts as follows: Cement, 380 pounds; Sand, 10 cubic feet; Broken Stone, 20 cubic feet; the sand and stone to be measured in suitable boxes approved by the Department. This method, with suitable inspection, will absolutely insure the proper proportions.

During the latter part of 1902, measuring boxes for sand were placed in operation on several of the contracts in Brooklyn.

The use of mechanical mixers should be confined by specifying "batch mixers" for such method, and the present broad and liberal sentence, "If a machine be used for mixing, the above operation may be varied as may be required," should be greatly modified.

Fourth—A most satisfactory check on the proportion of the materials used for concrete may be had by keeping an account of the total amounts of cement, sand and stone that are used for any period, since a comparatively simple computation will then show what proportions are being used in the work. The same end may also be accomplished in another way, although it cannot be considered as accurate. An account is kept of the cement used for any period, and the amount of concrete laid during that time is measured. Then knowing the amount of concrete that a barrel of cement, properly mixed, should make, the rest is plain. The inaccuracy in the above with respect to foundations for streets lies in the fact that the concrete must be of exceptionally uniform depth to show the correct quantity, the difference of $\frac{1}{2}$-inch in the depth of the concrete over the distance of one city block for the width of the pavement making a very considerable variation in the computation. Both methods are approximate, but serve as excellent checks, and the specifications should require the contractor to furnish this data whenever required, in addition to the account kept by the inspector.

Fifth—The broken stone should be limited to trap, granite or limestone since it does not appear that the cost of the work to the City is cheapened by allowing the use of stone taken from the line of the work, and the latter is certainly largely productive of violations of the specifications.

Attached to this report will be found copies of reports previously made by me and Mr. Benjamin F. Welton, Examining Engineer, on work of this nature in the Borough of Brooklyn.

The chemical analyses on which the discussions in this report are based were made by the chemist of this Department, Professor S. F. Peckham, and the physical tests were in charge of Mr. Benjamin F. Welton, Examining Engineer.

In conclusion, I beg to call your attention to the fact that extensive experiments regarding the crushing or compressive strength of concretes had been contemplated, which tests would be extremely valuable if not necessary, but on account of not having at our disposal a testing machine of the required capacity, as requested, this essential part of the work had to be omitted.

Respectfully submitted,

OTTO H. KLEIN,
Chief Engineer.

(Copy.)

ENGINEER'S REPORT NO. 229.

NEW YORK, September 2, 1902.

SUBJECT: *Report on Examination of Concrete used in the Foundation of a Granite Block Pavement on Court Street, from Hamilton Avenue to Bryant Street, Borough of Brooklyn.*

Hon. COMMISSIONERS OF ACCOUNTS,
New York City:

GENTLEMEN—Numerous complaints have been made of late by my Engineers and Examiners regarding concrete foundation for asphalt and granite block pavements laid with "Invicta" Portland cement in the Borough of Brooklyn. This brand of cement has been analyzed in this Laboratory and reported on previously, owing to its failure to come up to the low requirements for tensile strength of the Bureau of Highways. In some instances, samples of this brand of cement, which were examined in our Physical Laboratory, just barely passed the requirements, and could therefore not be objected to.

In several instances concrete made with the "Invicta" Portland cement does not show a proper set after having been down a sufficient period.

I beg to call your special attention regarding this latter

failure, to the concrete foundation laid for the granite block pavement on Court street, from Hamilton avenue to Bryant street, Borough of Brooklyn,

The concreting on this street was commenced on July 23, and a sample of "Invicta" Portland cement used on this work was obtained by W. L. Dusenberry, Engineer, which gave the following average results of tensile strength in pounds per square inch:

Sample 214.		Requirements of Bureau of Highways.	
1 Day Neat, ...	275 lbs.	1 Day Neat,.....	200 lbs.
7 " "....	413 "	7 " "....	400 "
7 " Sand (1-3).	160 "	7 " Sand (1-3).	150 "

It will be readily seen from the above tables that this sample does not run very high above the requirements, which a good Portland cement should do.

Subsequent visits on this work of my Engineers and Inspectors resulted in unfavorable reports regarding the setting qualifications of the cement under consideration.

On August 13th, accompanied by Inspector Brown, I made a personal inspection of the concrete in place, on which occasion I found the complaints of my men fully justified. The Inspector of the Bureau of Highways on this work supplied me with two samples of the concrete, which were located and taken out in my presence and brought to this office for further examination.

In order to remove all doubts as to the cause of failure of this concrete, chemical analysis was made of these samples, an analysis of a sample of "Invicta" cement having been made previously.

The samples were marked for identification Laboratory Nos. 436B and 436C, and the examination gave the following results:

436B was loose in the box, the mortar having been almost completely removed from the stone. The small portion of mortar still adhering to the stone was easily removed by the fingers and a brush. The whole of the sample was weighed, the

Stone weighing	2,464	grams, equal to	66.4 per cent.
Mortar "	1,247	" " ..	33.6 "
Total,	3,711	"	

The stone was of good quality with the proper proportion of coarse and fine material.

Ten grams of the mortar was weighed, after it was thoroughly air dried, and dissolved in 10 per cent. HCl, with violent effervescence, indicating a large proportion of carbonate acid. The analysis gave :

Insoluble in HCl.	75.407 per cent.
Soluble Silica	2.086 "
Alumina and Ferric Oxide	.146 "
Lime.....	11.235 "
Undetermined	11.125 "
	100.000

436C was a coherent mass. It was easily crushed, and the mortar could be easily detached from the stone with the thumb nail. While sufficiently stable to hold together it was very weak. A portion was broken up and weighed, the

Stone weighing	847	grams, equals	67.13 per cent.
Mortar "	428	" "	32.87 "
Total....	1,302	"	

The stone was of good quality with the proper proportion of coarse and fine material.

Ten grams of the mortar was weighed, after it was thoroughly air dried, and dissolved in 10 per cent. HCl, with effervescence, but less violent than in the case of 436B, indicating the presence of a notable proportion of carbonic acid. The analysis gave :

Insoluble in HCl.....	75.419 per cent.
Soluble Silica.....	2.847 "
Alumina and Ferric Oxide.....	.1875 "
Lime	10.5500 "
Undetermined	10.9965 "
	100.0000 "

The analysis of 436C indicates a slightly better cement than 436B. The results of these analyses indicate the use of a cement containing a large amount of carbonic acid, and similar to that which was used on Watkins street in the Borough of Brooklyn, which was anaylzed in this laboratory together with samples of the concrete made from it, and the results of these analyses were discussed in a report made and submitted to the Commissioners of Accounts, May 14, 1901. There is this difference to be observed, that the concrete used on Watkins street was of better quality than the samples numbered 436 B and C.

The same method of separation and the same sieve was used in separating the stone from the mortar in the examination of all the samples, so far as analysis at this Laboratory is concerned. While the proportions in the Watkins street concrete were 60 and 63 per cents., in numbers 436 B and C the proportions were 67 and 66 per cents.

The proportions of matter in the Watkins street concrete insoluble in 10 per cent. HCl were 70 and 71 per cents., in numbers 436 B and C it was 75.4 per cent. These results indicate either the use of a larger proportion of stone to cement, or the use of a cement of poorer quality or perhaps both.

The results of the analysis of these two samples are so nearly identical that for practical purposes they may be considered as samples of the same cement. The work done in this laboratory has shown that in American Portland cements of good quality, at least 85 per cent. is soluble in 10 per cent. HCl. Of this portion, so dissolved, the lime should be equal to the sum of the soluble silica multiplied by 2.8 plus the alumina and ferric oxide taken together and multiplied by 1.1. Taking the sample numberd 436B and applying this formula, it is found that the percentage of soluble silica, 2.086×2.8 equals 5.84, and the percentage found of alumina and ferric oxides, $.146 \times 1.1$ equals 0.160. 5.84 plus .160 equals 6.00. 6 per cent. of lime is all the lime that can be made to combine with soluble silica, alumina and iron oxide found in this concrete, while the

lime actually found by analysis in the concrete numbered 436B, was almost double that amount, or 11.126 per cent. This excess of lime of 5.126 per cent. may be considered as practically in combination with carbonic acid in the form of inert limestone, the presence of which is confirmed by the violent effervescence when the mortar is dissolved in dilute acid. The presence of the carbonic acid and of the lime in excess of the amount of lime that can combine with the soluble silica, alumina and iron oxide to form cement, indicates the use of either a very good cement that had been spoiled by ageing or a cement made of good materials that were only partially burned, or what is most likely a cement that is adulterated by being ground with unburned cement rock.

The fact has been demonstrated again and again in this laboratory that Portland cement is soluble in 10 per cent. HCl and that in cements of good quality, the proportions of lime, soluble silica and alumina and iron oxide are very nearly those indicated by the above formula. It is therefore demonstratable that, in this instance, the amount of cement which was expected to hold together the concrete numbered 436B is only 12 per cent. of the mortar in the air dried concrete by weight. The remaining 88 per cent. is inert matter possessing no cementing properties, no matter whether it is quartz, sand or carbonate of lime, or whether it is finely or coarsely divided, the result is exactly the same. The amount of cement in the concrete is 12 per cent. of 32.87 per cent. of mortar or 3.94 per cent. not quite 4 per cent. of the mass.

It is no wonder that asphalt streets laid on such concrete foundations go to pieces, as the foundation of an asphalt pavement is the most vital part of its life.

No Portland cement mortar of good quality should effervesce when introduced into dilutè hydrochloric acid. Carbonic acid is not a legitimate constituent of Portland cement mortar.

In conclusion, I beg to call your special attention to the important features contained in this report.

City officials cannot be careful enough in the selection of a suitable Portland cement to secure permanent street foun-

dations and second class cements should be entirely excluded from use for work where such enormous amounts are yearly expended.

Respectfully submitted,

(Signed) OTTO H. KLEIN,
Chief Engineer,
Commissioners of Accounts.

(Copy.)

ENGINEER'S REPORT No. 233.

NEW YORK, September 22, 1902.

SUBJECT: *Report on defective concrete on Third avenue, from Twenty-sixth street to Thirty-eighth street, Borough of Brooklyn.*

Hon. COMMISSIONERS OF ACCOUNTS,
New York City:

GENTLEMEN—I beg to call your attention to the concrete foundation for the granite block pavement on Third avenue, from Twenty-sixth street to Thirty-eighth street, Borough of Brooklyn, James P. Graham, contractor, which deserves severe criticism.

In consequence of unfavorable reports by my Engineers and Inspectors that the concrete in place did not show any set after a sufficient period, a sample of the concrete was brought to this office, subjected to an examination and chemical analysis with the following results:

The concrete was marked for identification No. 450, and was found to consist of:

Stone,	1,319	grams,	equal to	68.95	per cent.
Mortar,	594	"	"	31.05	"
Total,	1,913	"	"	100.00	"

Owing to the defective cohesion of the particles, the concrete could not be recovered from the street in a solid mass, but readily broke to pieces, and was, therefore, brought loose in a box to this Laboratory, where the mortar and stone were easily separated by means of a sieve and brush.

Ten grams of mortar were subjected to the action of 10 per cent. HCl. which dissolved with violent effervescence 18.35 per cent., leaving an insoluble residue of 81.65 per cent. The 18.35 per cent. included the carbonic acid which escaped.

An analysis of the solution yielded of:

Insoluble in 10 per cent. HCl....	81.65	per cent.
Soluble Silica	1.30	"
Alumina and Ferric Oxide.....	.740	"
Calcium Oxide or Lime.....	8.50	"
Undetermined.....	7.81	"
Total	100.00	"

This concrete is of the same class as that taken from Court street, reported on September 2, 1902, only it is not as good. It contains the smallest proportion of cement mortar and the largest proportion of stone that has been brought to this office. Only about half the lime is in combination to produce mortar, the remainder being in combination as carbonate of lime to form limestone.

The lime present to form cement is only 8.5 per cent. of 31.05 per cent., or only 2.64 per cent., an amount of lime wholly inadequate for such a purpose.

The probability of any further appreciable setting or hardening of this concrete is therefore excluded.

The cement used for this concrete was the "Invicta" brand, and passed the requirements, although the sand test was not far above the requirements. The poor showing of the concrete must be adjudged to the small amount of cement used as above stated.

I find this condition to be caused by insufficient inspection and the system of mixing and measuring of the proportions

of cement, sand and stone, which is deficient, and I will report on this matter as soon as our special investigations on this subject, which are going on at the present time, are completed.

Respectfully submitted,

(Signed) OTTO H. KLEIN,
Chief Engineer,
Commissioners of Accounts.

Telephone "4315 Franklin."

OFFICE OF THE COMMISSIONERS OF ACCOUNTS,
ROOMS 104, 105, 115, 119 & 121,
STEWART BUILDING, NO. 280 BROADWAY,
NEW YORK, October 31, 1902.

Wm. Hepburn Russell,
Edward Owen,
Commissioners.

Mr. OTTO H. KLEIN,
Chief Engineer, Commissioners of Accounts,
New York City:

SIR—Following is a somewhat detailed report of the prosecution of the contract work of R. & P. with granite block on concrete foundation, Third avenue, Brooklyn, from Twenty-sixth street to Thirty-eighth street, in so far as it has been criticised by the Engineers and Inspectors of this Department.

About August 15, 1902, concrete work was started on the line of the street. On August 20 it was reported that the pavement was being laid before the concrete had had time to set properly. On August 29 the quality of the concrete was criticised, and a sample of same taken. On September 9 a sample of cement was brought to the office, which passed the requirements of the specifications, the margin in the sand tests being small, however.

On September 29 and 30 and on October 2 and 13 it was noticed that the concrete was not setting well, and on the

two latter dates oversize stone in the concrete and muddy sand under the paving blocks were reported.

On October 16, and on all following inspections, the excessive size of the broken stone has been referred to, as well as the fact that the concrete is sadly lacking in mortar. The superintendent for the contractor has tried to excuse the oversize stone by laying the blame on the crusher, which is no excuse.

The joints between the paving-stones have not been properly filled with paving cement, many good-sized cracks being open, although a partial attempt to remedy this has been made lately. Such a condition is highly detrimental to any pavement. The surface water will enter, freeze, thaw, etc., and rapidly disintegrate same. Moreover, the refilling at a subsequent period does not accomplish the desired result, as dirt and dust have in the meanwhile partially filled the cracks, preventing a good bond, and still allowing the admission of water.

Regarding the lack of mortar in the concrete, I will say that on the occasion of my last visit to this work, when it was almost completed, the inspector was absent and the contractor's men had just finished mixing a batch of concrete which was being placed on the street. This batch was almost devoid of mortar and excessively wet. It had the appearance of broken stone which had been dumped in a mud puddle and then raked out, leaving only a thin coating of mud on the stone. When the same was tamped, the voids due to the large stone and lack of mortar were very much in evidence, and mortar from another batch that was just being mixed was shoveled on top and spread without tamping to cover up the bad work.

This lack of mortar had been previously noted on other occasions, once by myself and once by one of the inspectors, so I am constrained to believe that it was the rule rather than the exception.

Judging by appearances, the inspection of the street by the Department of Highways could not have been effective.

On September 22, 1902, you made a report to the Hon.

Commissioners of Accounts on the analysis of the sample of concrete recovered which fully corroborates the above criticism.

Respectfully,

BENJAMIN F. WELTON,
Examining Engineer.

(Copy.)

ENGINEER'S REPORT No. 241.

NEW YORK, October 4, 1902.

SUBJECT: *Report on defective concrete used as foundation for Granite Block Pavement on Forty-second street, from First avenue to Third avenue, Borough of Brooklyn.*

Hon. COMMISSIONERS OF ACCOUNTS,
New York City:

GENTLEMEN—Owing to the deficient set or hardening of the concrete used in the foundation for a Granite Block pavement on Forty-second street, from First avenue to Third avenue, Borough of Brooklyn, Maurice Hickey, contractor, I instructed Mr. W. L. Dusenberry, Examining Engineer, to bring a sample of the concrete in question to this Laboratory for analysis. On September 24, Mr. Dusenberry was handed a piece of concrete by the inspector on this work, as being a fair sample of the concrete in place.

The concrete consisted of pieces of crushed stone and mortar, with almost no small stone, and very little gravel. There was nothing consequently to fill the large voids betweeen the stone, and there was no bond between the soft mortar and the stone; the stone readily separating from the mortar with clean surfaces. While the concrete was sufficiently stable to hold together, it was very easily broken, and the mortar could be readily broken between the fingers, and rubbed into a coarse powder.

Air dried, the portion weighed:

Stone,	1,219	grams, equals	57.55 per cent.	} .. 59.15	per cent.
Gravel,	34	" "	1.60 "		
Mortar,	865	" "	..... 40.85		"
Total..	2,118	" "	Total.....	100.00	"

Ten grams of the mortar dissolved in 10 per cent. HCl with violent effervescence, and the

Insoluble residue was	66.413	per cent.
Soluble silica.....	4.423	"
Alumina and ferric oxide.....	1.595	"
Lime.	18.220	"
	90.651	"

The undetermined portion, consisting largely of carbonic acid, amounted to 9.249 per cent.

Computing the cement according to Newberry's formula: 4.423 x 2.8 equals 12.384, plus 1.595 x 1.1 equals 1.7454, equals 13.138.

13.138 per cent. from 18.22 equals 5.082 per cent. 5.082 per cent. equals the percentage of lime found over that which is in combination with soluble silica, alumina, and iron oxide to form cement. In other words, the dry mortar contains only 13.138 per cent. of pure cement, or if we consider the commercial cement of first quality to be 90 per cent. pure, the mortar contains 14.596 per cent. of cement of first quality, when it ought to contain 24.46 per cent. of such cement.

It is not suprising that concrete consisting of only a little more than half the cement that it ought to contain should be very weak and friable.

Cement used for concrete is the "Invicta" Portland.

Respectfully submitted,

(Signed) OTTO H. KLEIN,
Chief Engineer,
Commissioners of Accounts.

(Copy.)

ENGINEER'S REPORT No. 243.

NEW YORK, October 7, 1902.

SUBJECT: *Report on personal inspection of Concrete Foundation for a Granite Block Pavement on Forty-second street, from First avenue to Third avenue, Borough of Brooklyn.*

Hon. COMMISSIONERS OF ACCOUNTS,
New York City:

GENTLEMEN—Owing to the numerous and continued complaints of my Engineers and Inspectors regarding the failure of many concrete foundations for pavements in the Borough of Brooklyn to harden, and also the neglect of the Bureau of Highways to restrain the contractors on such objectionable contract works from laying the pavement proper on these unstable foundations, I made yesterday a personal inspection of the concrete foundation for a granite block pavement on Forty-second street, from First avenue to Third avenue, Borough of Brooklyn.

Several weeks ago I called up the Highways Bureau, Borough of Brooklyn, and in the absence of Mr. Tillson, Chief Engineer, I had a conversation over the telephone with his assistant, Mr. C. K. Pollock. I informed Mr. Pollock of the various streets where the concrete foundations were found objectionable by my men, and spoke to him of the advisability, in the interests of both the City and the contractor, to delay the work of covering up the concrete foundation until such a period that the deficiency of the concrete could be proven and demonstrated beyond any question, examinations made without tearing up the pavement proper, and further arrangements taken.

Mr. Pollock promised me then to look into the matter, examine those concretes and communicate with me again. Not receiving any reply from Mr. Pollock, I again communicated with the Highway Bureau, and spoke to Mr. Tillson

in the same tenor. He agreed with my proposition, and advised me that he would make a personal inspection of the following streets, where I had reason to question the firmness of the concrete :

Forty-second street, First avenue to Third avenue.

Third avenue, Twenty-sixth street to Thirty-eighth street.

Prospect avenue, Fourth avenue to Seventh avenue.

High street, Jay street to Bridge street.

Mr. Tillson did not inform me of his findings, and as my men reported that the contractors were progressing with covering up the foundations of the streets, I again, on Friday, October 3, called up Mr. Tillson on the telephone in order to inform him of my intention of making a personal inspection of Forty-second street, which was nearing completion ; also inviting Mr. Tillson to be present. Mr. Tillson intimated that he probably would be able to be present on Monday, the 6th instant. I again telephoned him on Monday and was informed that he could not meet me before the end of the week, owing to an intended trip out of tonw. Fearing by that time the work would be completed and the entire street covered up with the pavement, I decided to make a personal inspection at once in the presence of one of our examining inspectors.

On October 4 I made a report to you on a piece of concrete taken from the Forty-second street contract and analyzed, showing a remarkable deficiency in cement.

The sample of concrete which was taken from the Forty-second street contract in my presence yesterday, at a place in the centre of the street, about 40 feet northwest of manhole near northerly line of Second avenue, and brought to this office, and which is herewith respectfully submitted, is the *worst piece of concrete made out of Portland cement which ever came under my observation.*

I am informed that this concrete has been laid for a period of from six to seven weeks from this date.

I beg to recommend this case, as well as the other contract works in the Borough of Brooklyn, where of late adverse reports have been made by me regarding defective

cements or concretes, to your special attention and immediate action.

The principal reasons for such a flagrant violation of the specifications must be attributed to insufficient and careless inspection, besides the use of second-grade cement.

According to the specifications the proportions of cement, sand and stone are to be one part cement, three parts sand, and six parts of broken stone, the latter to be entirely free from dirt and dust, and to vary from one-half (½) inch to two and one-half (2½) inches in extreme dimensions. This clause is being almost constantly violated owing to the fact that where concrete-mixing machines are used, there is no adequate system of measuring the various ingredients exercised, but the stone on one side, and the cement and sand on the other side shoveled in at random.

I highly recommend the adoption of an improved system of control in measuring the various dry ingredients of concrete, also the amount of water, and that the mixing is done thoroughly before the concrete is placed in position and well rammed.

The grouting of the surface of the concrete, as it is done occasionally, is unnecessary, but only tends to deceive casual inspection by the City officials interested, who, I am informed, very rarely make an examination of the interior of the concrete in place, but merely judge the quality of the concrete by surface inspections.

Respectfully submitted,

(Signed) OTTO H. KLEIN,
Chief Engineer,
Commissioners of Accounts.

(Copy.)

ENGINEER'S REPORT No. 257.

NEW YORK, December 10, 1902.

Hon. COMMISSIONERS OF ACCOUNTS,
New York City:

GENTLEMEN—I have to advise you that the concrete foundation laid under the contract for repaving with asphalt, on concrete foundation, Hopkins street, between Nostrand and Throop avenues, Brooklyn, is of a very poor quality, and I do not consider that it is a suitable foundation for said pavement. Many severe criticisms regarding this work have been made by my assistants and numerous samples have been recovered which are now under examination. The fact that the concrete is very poor is clearly shown by the fact that the Department of Highways has compelled the contractor to remove and replace the same, in probably, over two hundred places. In my opinion, the concrete on the entire street should be relaid and no further work should be carried on until this is done. If the concrete had been made from the best quality of Portland cement, as required by the specifications, there would be no question as to its quality.

When the investigations now in progress and the analyses of the specimens of concrete, etc., which are under examination by us have been completed, I intend to make a report in full on this and other work in Brooklyn, and pending the completion of the same, I would recommend that further payments to the contractor on this work be withheld.

In conjunction with the above recommendation, I would also respectfully advise that all payments on the contract for repaving Forty-second street, from First to Third avenues, Borough of Brooklyn, be withheld until the contractor has replaced the present concrete foundation with one that is satisfactory. I have criticised this concrete in a report made to you, dated October 7, 1902, and a letter of

Mr. Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment, to his Honor, the Mayor, dated October 18, 1902, fully substantiates me in the same, but he proposes a method of settlement which I do not consider the Brooklyn Bureau is justified in entertaining.

" I quote from Mr. Lewis' letter:

" I have, on several different occasions, examined " work now in progress and in which the " Invicta " " Portland cement, which is the subject of most of the " complaints, is being made. Upon making inquiry of " the Chief Engineer of Highways of the Borough of " Brooklyn as to whether the concrete on Forty-second " street had been covered or not, I was advised that the " pavement had been completed, but that it was pur- " posed to open it in a number of places in order to " permit a thorough examination of the concrete, and " I was invited to be present when this was done. In " accordance with this invitation, I accompanied the " Commissioner of Public Works and the Chief Engi- " neer of the Bureau of Highways when a number of " openings were made in the granite-block pavement on " Forty-second street. The condition of the concrete " revealed by these openings was such as to justify " the complaint of the Commissioners of Accounts, and " in a number of places it corresponded closely with the " sample submitted to you by them. The granite-block " pavement I found to be unusually well laid, joints " having been filled with a Portland cement grout, this " being the first instance of the use of a joint of this kind " in Brooklyn, and one which promises well; the surface " of the pavement is very satisfactory, but the founda- " tion cannot be called good Portland cement concrete. " The character of the work being apparent, the Com- " missioner and the Chief Engineer discussed, in my " presence, the proper course to be followed, whether " to have the entire pavement and concrete foundation " removed and a new foundation laid, or whether to de- " duct from the final payment to the contractor an

" amount sufficient to represent the difference between
" Portland cement concrete, such as he was supposed
" to lay, and broken stone and sand, which is about
" what was found under the pavement. It was not posi-
" tively determined which course to pursue. It seems
" to me, however, that as the pavement is an excellent
" surface, the City would be justified in paying the con-
" tractor for what it had received, namely, a foundation
" of broken stone, and such a foundation, I may add, is
" not a bad one, although, of course, not equal to one
" of good cement concrete."

Any action that may be taken by the Brooklyn Department relative to the acceptance of Forty-second street by allowing the contractor, in the final payment, to be paid for a foundation of broken stone instead of the good concrete that should be there, it appears to me would be the worst possible course to pursue, since it would seem to condone very bad concrete, if indeed it is not putting a premium on generally poor workmanship. If this precedent should be established, a contractor might mix sand and water together for concrete, and if he succeeded in completing his work quickly enough, he could claim payment for a sand foundation (which is not a bad one for granite block) with a chance that he might be paid for concrete.

Moreover, I do not consider that the Engineer has this latitude in view of the clauses of the contract which are quoted below. It appears to me that the contract specifically states what shall be done under such circumstances, and I can see no better reason for the Engineer to violate the contract than for the contractor. My understanding of the contract is that the Engineer does not have the right to accept the street unless the specifications have been fully complied with, and as he admits the poor character of the concrete, it seems to me that there is only one course to pursue.

Below are the clauses of the contract referred to:

" (*c*) The president shall appoint such person or per-
" sons as he may deem necessary to properly inspect

" the materials to be furnished and the work to be done " under this agreement, and see that the same strictly " correspond with the specifications hereinafter men- " tioned and contained, such material and workmanship " to be always subject to the approval of the Engineer ; " the specifications, the proposals for estimates hereto " prefixed, and the bid or estimate of the contractor and " the plan now on file in the Bureau of Highways, are " hereby made part and parcel of this agreement, and " no inspection, approval or acceptance of any part of " the work herein contracted for or of the materials used " herein, or any payment on account thereof, shall pre- " vent the City from objecting to the acceptance of said " work or materials at any time thereafter during the " existence of this contract.

(*e*) To prevent all disputes and litigations " the " Engineer shall in all cases determine the amount or " the quality of the several kinds of work which are to " be paid for under this contract, and he shall determine " all questions in relation to said work and the con- " struction thereof, and he shall in all cases decide every " question, which may arise relative to the execution of " this contract on the part of the contractor, and his " estimate and decision shall be final and conclusive and " such estimate and decision, in case any question shall " arise, shall be a condition precedent to the right of the " contractor to receive any money under this contract.

" *The Engineer shall inspect the materials furnished* " *and the work done under this agreement and see that* " *the same strictly correspond with the specifications*, " and if the work, or any material brought on the " ground for the use of the work, or selected for the " same, shall be condemned by the Engineer as un- " suitable or not in conformity with the specifications, " the contractor shall forthwith remove such materials " from the work.

" (*g*) The work shall be performed in the best manner " and all materials of which the work is composed shall

" be of the best kind, and a sufficient number of per-
" sons shall be at all times employed to execute the
" work with due dispatch, the whole to be done to the
" satisfaction of the Engineer, *and any materials*
" *furnished or work done not satisfactory to the Engi-*
" *neer shall be immediately removed and satisfactorily*
" *replaced by the contractor;* or if he shall neglect or
" refuse to remove the same when notified to do so by
" a written notice to be served upon the contractor,
" either personally or by leaving it at his residence or
" with his agent in charge of the work, then the Presi-
" dent may remove, or cause the same to be removed
" and satisfactorily replaced, by contract or otherwise,
" as he may deem expedient, and charge the expense
" thereof to the contractor; and the expense so charged
" shall be deducted and paid by the party of the first
" part out of such moneys as are or may become due
" under this agreement.

" *Should any work be found defective or improperly*
" *done, such defective or improper work shall be taken*
" *up and relaid or be otherwise remedied to the satisfac-*
" *tion of the Engineer;* and should the contractor refuse
" or neglect to correct such defective work when noti-
" fied to do so by a written notice to be served on the
" contractor either personally or by leaving it at his
" residence or with any of his agents in charge of the
" work, or employees found on the work, then the
" President shall employ the necessary men and ma-
" terials to do the work, and the expense thereof shall
" be deducted from any moneys that may be due the
" contractor on account of this contract.

" (e) *The contractor will not be entitled to demand or*
" *receive payment for any portion of the aforesaid work*
" *or materials, unless the same shall be fully completed*
" *in the manner set forth in this contract and specifica-*
" *tions,* and such completion shall be duly certified by
" the Chief Engineer of the Bureau of Highways, and
" until each and every one of the stipulations hereinbe-

" fore mentioned are complied with, and the work com-
" pleted to the satisfaction of the President, and accepted
" by him, and the certificate thereof signed by the Pres-
" ident and Chief Engineer and filed with the Comp-
" troller; whereupon the party of the first part will pay,
" and hereby binds itself and its successors to pay, to
" the Contractor in cash, on or before the expiration of
" thirty days from the time of the completion of the
" work and the acceptance of the same by the President,
" the whole of the moneys accruing to the Contractor
" under this contract, less any amount retained under
" the provisions of this contract.

" (*q*) The party of the first part shall not, nor shall
" any Department or officer of the City of New York,
" be precluded or estopped by any return or certificate
" made or given by any Engineer or Inspector or other
" officer, agent or appointee of said Borough President
" or party of the first part, under or in pursuance of
" anything in this agreement contained, from at any
" time showing the true and correct amount and char-
" acter of the work which shall have been done and
" materials which shall have been furnished by the
" Contractor or any other person or persons under this
" agreement."

Respectfully submitted,

(Signed) OTTO H. KLEIN,
Chief Engineer,
Commissioners of Accounts.

(Copy.)

ENGINEER'S REPORT No. 266.

NEW YORK, Jan. 26, 1903.

Hon. COMMISSIONERS OF ACCOUNTS,
New York City.

GENTLEMEN—I beg to submit the following data, relative to the repaving of Hopkins street between Nostrand and

Throop avenues, Brooklyn, in compliance with a request from Deputy Comptroller, J. W. Stevenson, for information concerning the following items:

(1) What was the proportion of cement used in the composition of the concrete so far as was observed by your Inspectors?

(2) Were repairs to the concrete properly made after defects were discovered?

(3) Was the cement used of the character approved by the Bureau of Highways?

In answer to the first item, I would say that during the visits of our Inspectors to this work while in progress, no serious violation of the specifications, regarding the proportions, were noted. The concrete was machine-mixed, and for further information, I quote in full the report of a special examiner, which explains itself.

(Copy.)

Mr. OTTO H. KLEIN,
Chief Engineer,
Commissioners of Accounts:

DEAR SIR—Report on concrete work done by the Inter-State Paving Company on Hopkins street, at and east of Tompkins avenue, Brooklyn.

1902.

Oct. 2.	Count of shovels full of material used.		
	9.55 A. M. to 10.10 A. M.	Shovels of Stone..	590
		Sand and Cement.	378
	An average of sand and cement to stone, quite.....		2/3
Oct. 2.	10.50 to 11.15 A. M.	Shovels of Stone.....	660
		Sand and Cement.....	437
	An average of sand and cement to stone, quite.....		2/3
Oct. 2.	1 to 1.20 P. M.	Shovels of Stone.....	220
		Sand and Cement.....	225
	An average of sand and cement to stone of..		45/44

Oct. 2.	1.30 to 1.50 P. M.	Shovels of stone.....	960
		Sand and Cement.....	694
	An average of sand and cement to stone, quite.....		2/3
Oct. 2.	2.50 to 3.10 P. M.	Shovels of Stone.....	780
		Sand and Cement.....	500
	An average of sand and cement to stone, quite.....		2/3

In mixing cement with sand it is quite difficult to determine the proportions of each to the other. To illustrate: at one time an area of sand is leveled off on an estimate of 8 feet square, with an estimate average of 3 inches thick; upon this is spread 5 bags of cement, then mixed.

Again, a windrow of sand is leveled off for, say, twice this distance, as above stated; upon this the cement is spread without reference to the number of bags of cement, but according to the judgment of the man in charge.

On October 3, at the same place, east of Tompkins avenue, the attention of the overseer, or boss, was called to the irregular mixing of sand and cement, and the reply was that he could not always be present; he stated, however, that the mixture consists of 7 barrows of sand to 5 bags of cement.

In measuring a barrow of sand, it required two and one-fourth bags of sand to fill the barrow. This would give 16 parts of sand to 5 parts of cement, or 5/16 approximately.

From 2.30 to 3.40 P. M., when our identity had become known, a count was made which gave 232 shovels of stone and 191 shovels of sand and cement, equal to about 19/23.

From statement above, it would seem that there is no scrimpage of material, but a lax method in mixing the material, which may cause weak spots in the concrete. At one time, it was quite noticeable that the mixture was coming from the machine too dry. This was remedied by flushing with water the spot where the dry material was placed.

Very truly yours,

(Signed) M. F. PENFIELD,
Special Examiner.

The proportions as determined by chemical analysis are mentioned under the next item.

Answering (2)—

The concrete foundation on Hopkins street, from Nostrand avenue to Throop avenue, has been criticised by this office since it was first laid. The concrete here has never acquired a satisfactory set. The Brooklyn Bureau attempted to remedy it by having the contractor remove the concrete in the places where it was plainly so bad as to be unfit for use and replace it by new concrete. This was done in a large number of places covering the entire extent of the contract. After this patchwork was completed, three samples of the concrete and one each of the cement and sand in use for patching were taken by this office. One sample was selected by the Inspector in charge of the repair work as the best he could find and another by the Contractor under the same stipulation. The third was selected by an Engineer from this office in a block which, according to the Inspector and Contractor, had been accepted by the Brooklyn Bureau as ready for the binder. In all cases it was with great difficulty that a sample of any considerable size could be obtained on account of the mortar crumbling away from the broken stone, leaving it clean, at the slightest blow of the pick.

In the opinion of the Engineer who took the samples, the tensile strength of the mortar could not have greatly exceeded 50 pounds per square inch. These samples were taken not more than a few feet from some of the numerous patches that had been completed, and are intended to show that the *patchwork method employed here is altogether inadequate to make the work satisfactory.* In fact, there is no first-class concrete on the work. The concrete had been in place about a month at the time the samples were taken. The analysis of these samples in the order mentioned (Nos. 472b, 472c, 472d) will be found in the following table. Those of two other samples, taken at an earlier date, are also shown (Nos. 472 and 472a), while the analysis of a briquette, mixed in the proper proportions in this office, using the cement and sand obtained as stated, is given for comparison

(No. 472f). The briquette in question showed a tensile strength of only 79 pounds per square inch.

Number.	472.	472*a*.	472*b*.	472*c*.	472*d*.	472*f*.
Per cent. of stone and gravel..	....	63.00	60.90	59.30	54.00	1.7
Per cent. of mortar.....	....	37.00	39.10	41.70	46.00	98.3
Analysis of Mortar.						
Insoluble in 10 per cent. HCl	77.62	80.61	74.60	73.92	79.37	74.63
Soluble silica.....	2.16	1.75	2.15	2.10	1.84	2.27
Alumina and ferric oxide.....	1.18	1.08	1.53	1.40	1.35	1.27
Lime	11.99	8.95	12.39	12.75	9.35	11.78

These results are all better than the actual proportions of the mixtures warrant, because a certain percentage of gravel that was not screened from the sand is included in the stone and at the same time actually belongs to the mortar. This result could not be avoided, as for purposes of analysis a uniform degree of fineness is a necessity of the operation. The gravel stones had to be taken out. If they had remained in, a larger percentage of the mortar would have appeared as " Insoluble in 10 per cent. HCl " and the other percentages would have been proportionately smaller. The results are therefore to a small percentage in favor of the cement.

The " ratio of cement found " is not the ratio of cement used, but the ratio of active cement present in the concrete computed from the results of analysis, as compared with corresponding results computed from proper materials mixed in proper proportions.

Every sample of this brand of cement which has been analyzed in this office has contained about 50 per cent. of inert finely-ground matter, which fact may account for failure of the concrete in many instances.

Of the four concretes, No. 472a contains an excess of stone. The other three are deficient in stone; an attempt having apparently been made to strengthen the concrete by using an excess of poor mortar, which was poor both from poor cement and an excess of sand, the result of which appeared in the weak concrete and in the low ratio (less than one-half) of the cement found to that required.

They all contained an excess of lime as carbonate, indicating a badly burned or adulterated cement. In either case, a cement that was not a "first-class Portland cement," as required by the specifications.

Answering (3)—

We assume that the character of the cement must have been approved by the Bureau of Highways, otherwise the contractor would not have been allowed to use it.

The regular tests of the same, made in this office, showed a tensile strength which passed the requirements of the specifications. A sample of the cement used in patching, when mixed with the sand in use on the street, in the proportion of 1 to 3, showed, however, an average of only 88 pounds per square inch, although the neat cement tested very well.

Respectfully submitted,

(Signed) OTTO H. KLEIN,
Chief Engineer,
Commissioners of Accounts.

TABLE "A"—CEMENTS.

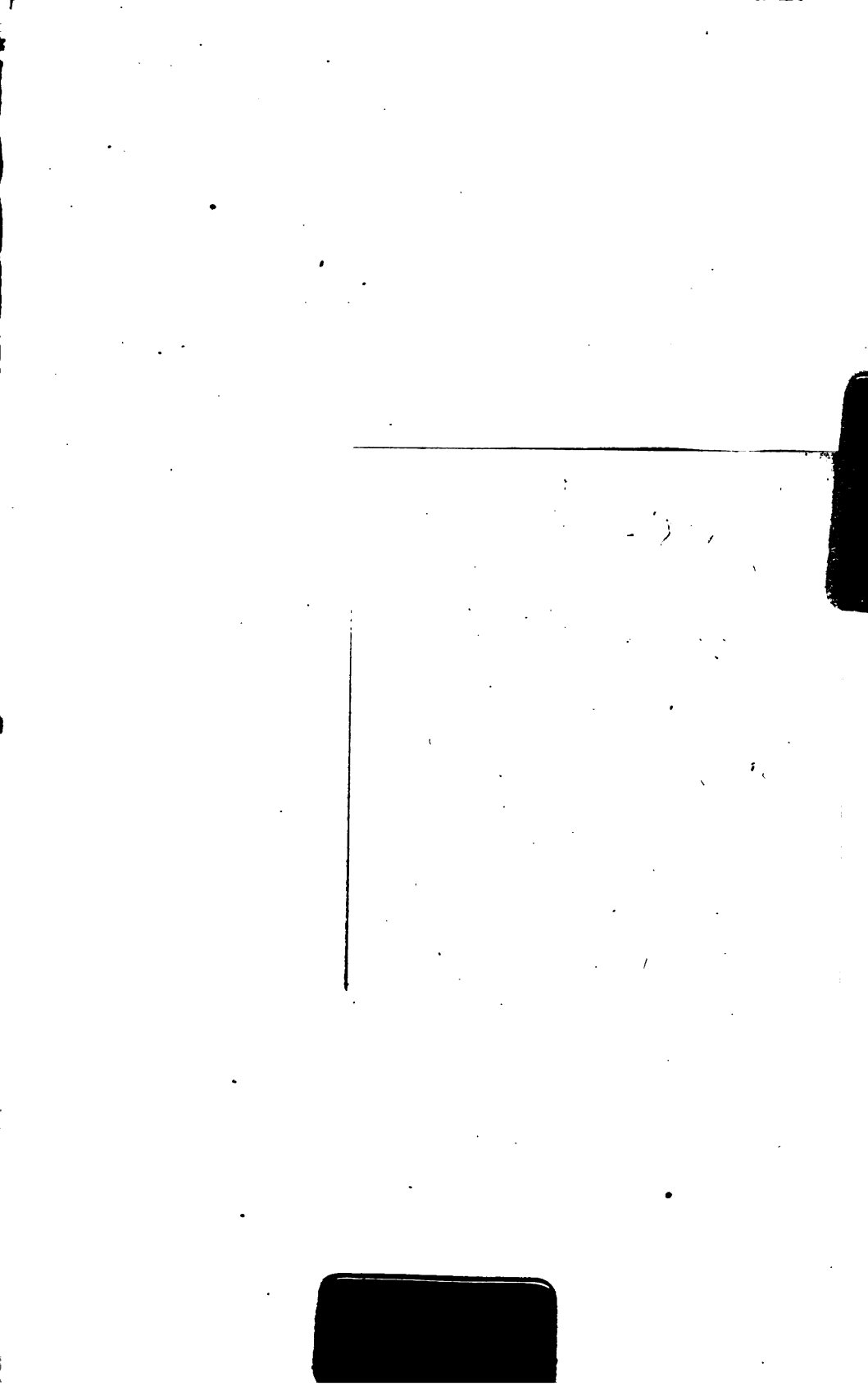
Number.	Laboratory Number.	DESCRIPTION.	Percentage of Cement Insoluble in 10% HCl.	Percentage of Soluble Silica.	Percentage of Alumina and Ferric Oxide.	Percentage of Lime.	Percentage Volatile at Red Heat.	Percentage of Active Cement by Newberry's Formula.	Percentage of Carbon, Magnesia and Sulphuric Oxide.
1	....	Average of Nos. 2 to 9.....	4.38	18.45	9.46	61.89	1.79	88.52	3.65
2	....	Atlas cement.....	4.43	17.96	9.35	60.06	3.04	87.88	5.96
3	524-A	" "	2.65	19.42	10.16	61.49	1.04	95.12	0.00
4	....	Alpha "	4.04	17.81	10.76	63.40	0.97	90.24	1.78
5	....	Ironclad "	4.42	18.26	11.00	59.86	1.62	92.49	2.56
6	....	Lehigh "	5.79	17.41	8.65	61.72	1.15	84.31	4.09
7	....	Vulcanite "	5.35	18.29	9.00	60.02	0.63	88.40	6.03
8	....	Sandusky "	3.79	19.43	8.34	63.44	1.39	83.01	1.89
9	....	Slag "	2.82	19.61	9.13	63.58	2.75	93.49	2.16
10	423	Invicta "	1.94	10.86	6.16	58.22	22.31	52.67	....
11	525-A	" "	2.87	11.60	5.99	57.96	19.57	56.26	....

TABLE "B"—CEMENT MORTARS.

Number.	Laboratory Number.	DESCRIPTION	Percentage of Mortar Insoluble in 10% HCl.	Percentage of Soluble Silica in Mortar.	Percentage of Alumina and Ferric Oxide in Mortar.	Percentage of Lime in Mortar.	Percentage of Mortar Volatile at Red Heat.	Percentage of Active Cement by Newberry's Formula.	Percentage Excess of Lime as Carbonate.	Equivalent to Carbonate of Lime.	Ratio of Cement Found to that Required.	REMARKS.
100	.....	Standard cement mortar	69.13	5.12	2.70	16.64	4.50	24.46	....	....	....	Estimated as shown in report.
120	508-A	Briquette mixed in office.....	68.19	5.08	2.72	16.34	6.03	24.08	....	...	0.98	Atlas cement and crushed quartz (1-3).
130	508-B	"	68.07	4.69	2.69	16.25	6.38	23.63	....	....	0.97	Atlas cement and commercial sand (1-3).
140	527-A	"	69.55	5.25	5.73	17.28	4.80	25.45	....	....	1.04	" " "
150	488-C	Briquette from mixing board..	71.30	4.59	2.49	14.46	6.07	21.54	....	....	0.88	Trowel cement and commercial sand.
160	489-B	" ..	72.14	4.28	2.19	14.69	6.26	21.16	....	....	0.87	Condor cement and commercial sand.
170	472-F	Briquette mixed in office.....	74.63	2.27	1.27	11.78	7.11	11.00	4.08	7.29	0.45	Invicta cement and commercial sand (1-3).
180	472	Mortar screened from concrete	77.62	2.16	1.18	11.99	6.94	10.47	4.76	8.50	0.43	From Hopkins street, Nostrand to Throop avenues.
190	479-A	"	80.78	1.64	1.10	8.36	7.81	7.95	2.87	5.13	0.32	From Kosciusko street, Lewis to Throop avenues.
200	528-A	Briquette mixed in office.....	73.42	2.69	1.75	13.86	7.70	13.03	4.86	8.68	0.53	Invicta cement and commercial sand (1-3).
210	487-H	Briquette from mixing board..	71.62	3.39	1.52	14.16	8.32	11.72	6.15	12.00	0.48	" " "

TABLE "C"—CONCRETES.

Number.	Laboratory No.	CEMENT USED IN CONCRETE.	Percentage of Stone in Concrete.	Percentage of Mortar Insoluble in 10% HCl.	Percentage of Soluble Silica in Mortar.	Percentage of Alumina and Ferric Oxide in Mortar.	Percentage of Lime in Mortar.	Percentage of Mortar Volatile at Red Heat.	Percentage of Active Cement by Newberry's Formula.	Percentage Excess of Lime as Carbonate.	Equivalent to Carbonate of Lime.	Ratio of Cement Found to that Required.	LOCATION OF CONTRACT FROM WHICH SPECIMEN WAS OBTAINED.
310	.....	.....	56.55	69.13	5.12	2.70	16.64	4.50	24.46	....	....	....	Estimated, as shown in Report on Concrete.
320	521–B	Trowel.....	61.53	67.97	5.43	3.27	18.18	4.84	26.32	0.00	....	1.08	Prospect Park, West, from Fifteenth to Nineteenth street.
330	521–A	"	65.60	62.80	5.23	3.20	18.87	4.67	25.35	1.36	2.43	1.03	" " " "
340	520–A	Saylor's.....	54.72	67.33	4.70	3.23	18.18	3.97	22.79	2.44	4.35	0.93	Park place, from Washington to Vanderbilt avenue.
350	453–B	Alsen's.....	73.50	65.05	4.55	6.09	16.01	9.41	22.06	0.77	1.37	0.90	Wolcott street, from Conover to Richards street.
360	52c–B	Saylor's	56.16	72.06	4.48	2.92	15.66	6.25	22.12	0.26	0.38	0.90	Park place, from Washington to Vanderbilt avenue.
370	519–A	Alsen's	61.33	70.75	4.26	2.96	16.85	4.10	21.07	2.32	4.14	0.86	Patchen avenue, from Decatur to Fulton street.
380	520–C	Saylor's.....	55.65	71.63	4.23	2.94	15.98	6.44	20.50	1.82	3.24	0.84	Park place, from Washington to Vanderbilt avenue
390	395–B	Victor	67.60	74.16	3.71	2.00	11.42	8.40	17.98	0.00	0.00	0.74	Watkins street, East New York avenue to New Lots road.
400	395–D	"	76.60	67.42	3.25	1.89	13.19	12.00	15.76	2.30	4.20	0.65	" " "
410	430–C	Invicta.....	67.13	75.42	2.85	1.87	10.55	8.13	13.83	1.00	1.80	0.57	Court street, from Hamilton avenue to Bryant street.
420	483	"	58.04	70.37	2.57	1.75	13.73	11.15	12.45	5.13	9.15	0.51	Floyd street, from Nostrand to Throop avenue.
430	487–C	"	65.00	74.20	2.29	1.14	12.07	9.15	11.09	4.41	7.88	0.45	Third avenue, from Sixtieth street to Shore road.
440	487–E	"	52.22	76.84	2.27	1.51	10.89	8.32	11.00	3.29	5.87	0.45	" " "
450	472–B	"	60.90	74.60	2.15	1.53	12.39	9.07	10.41	5.20	9.30	0.43	Hopkins street, from Nostrand to Throop avenue.
460	472–C	"	59.03	73.92	2.10	1.40	12.75	9.34	10.18	5 72	10.22	0.42	" " "
470	436–B	"	66.40	75.41	2.09	1.46	11.23	8 92	10.12	4.24	7.57	0.42	Court street, Hamilton avenue to Bryant street.
480	457	Atlantic.....	72.60	79.29	2.07	1.02	9.54	5.11	10.13	2.61	4.66	0.42	H gh street, from Jay to Bridge street.
490	487–B	Invicta.....	63.90	77.39	1.91	1.22	9.23	8.92	8.25	2.84	5.07	0.34	Third avenue, from Sixtieth street to Shore road.
500	472–D	"	54.00	79.37	1.84	1.35	9.35	7.76	8.92	3.19	5.69	0.30	Hopkins street, from Nostrand to Throop avenue.
510	472–A	"	03.00	80.61	1.75	1.08	8.95	6.89	8.48	3 09	5.52	0.35	" " "
520	479	"	65.60	77.28	1.74	1.63	9.22	9.03	8.44	3.39	6.03	0.35	Kosciusko street, from Lewis to Throop avenue.
530	471	Atlantic.....	59.00	77.57	1.70	1.06	9.89	7.40	8.24	4.20	7.50	0.34	Prospect avenue, from Fourth avenue to Seventh avenue.
540	395–C	Victor	77.00	72.32	1.53	0.84	7.09	7.77	7.32	2.02	3.61	0.30	Watkins street, East New York avenue to New Lots road.
550	487–A	Invicta.....	60.30	82.62	1.41	0.85	7.96	6.58	6.13	4.02	7.18	0.25	Third avenue, from Sixtieth street to Shore road.
560	450	"	68.95	81.65	1.30	0.74	8.50	8.70	6.30	4.15	7.43	0.26	Third avenue, from Twenty-sixth to Thirty-eighth street.
570	480	"	70.80	75.03	1.16	1.55	12.03	8.79	5.50	8.27	14.77	0.23	Maujer street, from Leonard street to Bushwick avenue.



Eng 809.03
Report on concrete foundatio
Cabot Science
3 2044 091 846